

1 WHAT IS CLAIMED IS:

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- 3 1. A method for hydroprocessing a hydrocarbon feedstock, said method
- 4 employing multiple hydroprocessing zones within a single reaction loop,
- 5 each zone having one or more catalyst beds, comprising the following
- 6 steps:
- 7
- 8 (a) passing a hydrocarbonaceous feedstock to a first hydroprocessing
- 9 zone having one or more beds containing hydroprocessing
- 10 catalyst, the hydroprocessing zone being maintained at
- 11 hydroprocessing conditions, wherein the feedstock is contacted
- 12 with catalyst and hydrogen;
- 13
- 14 (b) passing the effluent of step (a) directly to a hot high pressure
- 15 separator, wherein the effluent is contacted with a hot, hydrogen-
- 16 rich stripping gas to produce a vapor stream comprising hydrogen,
- 17 hydrocarbonaceous compounds boiling at a temperature below the
- 18 boiling range of the hydrocarbonaceous feedstock, hydrogen
- 19 sulfide and ammonia and a liquid stream comprising
- 20 hydrocarbonaceous compounds boiling approximately in the range
- 21 of said hydrocarbonaceous feedstock;
- 22
- 23 (c) passing the vapor stream of step (b) after cooling and partial
- 24 condensation, to a hot hydrogen stripper containing at least one
- 25 bed of hydrotreating catalyst, where it is contacted countercurrently
- 26 with hydrogen, while the liquid stream of step (b) is passed to
- 27 fractionation;
- 28
- 29 (d) passing the overhead vapor stream from the hot hydrogen
- 30 stripper/reactor of step (c), after cooling and contact with water, the
- 31 overhead vapor stream comprising hydrogen, ammonia, and
- 32 hydrogen sulfide, along with light gases and naphtha to a cold high
- 33 pressure separator, where hydrogen, hydrogen sulfide, and light

- 1 hydrocarbonaceous gases are removed overhead, ammonia is
- 2 removed from the cold high pressure separator as ammonium
- 3 bisulfide in the sour water stripper, and naphtha and middle
- 4 distillates are passed to fractionation;
- 5
- 6 (e) passing the liquid stream from the hot hydrogen stripper/reactor of
- 7 step (c) to a second hydroprocessing zone, the second
- 8 hydroprocessing zone containing at least one bed of
- 9 hydroprocessing catalyst suitable for aromatic saturation and ring
- 10 opening, wherein the liquid is contacted under hydroprocessing
- 11 conditions with the hydroprocessing catalyst, in the presence of
- 12 hydrogen;
- 13
- 14 (f) passing the overhead from the cold high pressure separator of
- 15 step (d) to an absorber, where hydrogen sulfide is removed before
- 16 hydrogen is compressed and recycled to hydroprocessing vessels
- 17 within the loop; and
- 18
- 19 (g) passing the effluent of step (e) to the cold high pressure separator
- 20 of step (d).
- 21
- 22 2. The process of claim 1, wherein the hydroprocessing conditions of
- 23 step 1(a) comprise a reaction temperature of from 400°F-950°F
- 24 (204°C-510°C), a reaction pressure in the range from 500 to 5000 psig
- 25 (3.5-34.5 MPa), an LHSV in the range from 0.1 to 15 hr⁻¹ (v/v), and
- 26 hydrogen consumption in the range from 500 to 2500 scf per barrel of
- 27 liquid hydrocarbon feed (89.1-445 m³ H₂/m³ feed).
- 28
- 29 3. The process of claim 2, wherein the hydroprocessing conditions of
- 30 step 1(a) preferably comprise a temperature in the range from
- 31 650°F-850°F (343°C-454°C), reaction pressure in the range from
- 32 1500-3500 psig (10.4-24.2 MPa), LHSV in the range from 0.25 to

- 1 2.5 hr⁻¹, and hydrogen consumption in the range from 500 to 2500 scf
2 per barrel of liquid hydrocarbon feed (89.1-445 m³ H₂/m³ feed).
3
- 4 4. The process of claim 1, wherein the hydroprocessing conditions of
5 step 1(e) comprise a reaction temperature of from 400°F-950°F
6 (204°C-510°C), a reaction pressure in the range from 500 to 5000 psig
7 (3.5-34.5 MPa), an LHSV in the range from 0.1 to 15 hr⁻¹ (v/v), and
8 hydrogen consumption in the range from 500 to 2500 scf per barrel of
9 liquid hydrocarbon feed (89.1-445 m³ H₂/m³ feed).
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- 11 5. The process of claim 4, wherein the hydroprocessing conditions of
12 step 1(e) preferably comprise a temperature in the range from
13 650°F-850°F (343°C-454°C), reaction pressure in the range from
14 1500-3500 psig (10.4-24.2 MPa), LHSV in the range from 0.25 to
15 2.5 hr⁻¹, and hydrogen consumption in the range from 500 to 2500 scf
16 per barrel of liquid hydrocarbon feed (89.1-445 m³ H₂/m³ feed).
17
- 18 6. The process of claim 1, wherein the feed to step 1(a) comprises
19 hydrocarbons boiling in the range from 500°F to 1500°F.
20
- 21 8. The process of claim 1, wherein the feed is selected from the group
22 consisting of vacuum gas oil, heavy atmospheric gas oil, delayed coker
23 gas oil, visbreaker gas oil, FCC light cycle oil, and deasphalted oil.
24
- 25 9. The process of claim 1, wherein the cetane number improvement
26 occurring in step 1(e) ranges from 2 to 15.
27
- 28 10. The process of claim 1, wherein the hydroprocessing catalyst comprises
29 both a cracking component and a hydrogenation component.
- 30 11. The process of claim 10, wherein the hydrogenation component is
31 selected from the group consisting of Ni, Mo, W, Pt and Pd or
32 combinations thereof.

- 1 12. The process of claim 10, wherein the cracking component may be
2 amorphous or zeolitic.
- 3 13. The process of claim 12, wherein the zeolitic component is selected from
4 the group consisting of Y, USY, REX, and REY zeolites.
5
- 6 14. The process of claim 1, wherein the second hydroprocessing zone of
7 step 1(e) is maintained at the same pressure as the first
8 hydroprocessing zone of step 1(a).